UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

MEMORANDUM July 27, 2004

Chemical: chlorsulfuron
PC code: 118601
DP bar code: D292626

SUBJECT: Revised assessment of risk to non-target plants associated with chlorsulfuron spray drift

From: Norman Birchfield, Senior Biologist

Peer Review: Kevin Costello, Risk Assessment Process Leader

Thru: Elizabeth Behl, Chief
Environmental Risk Branch 4
Environmental Fate and Effects Division (7507C)

To: Christina Scheltema,
Susan Jennings
Special Review and Reregistration Division (7508C)

Summary

The following assessment is focused primarily on chlorsulfuron use on crops and is intended to accurately reflect the most important application conditions actually used in applying chlorsulfuron to assess spray drift risks to non-target plants. Application parameters used by aerial applicators in Washington and Oregon were used to estimate a range of spray drift levels in this assessment. Reports of set ups for ground boom applications were not available and thus ground boom configurations were assumed to include the range of values available in the

AgDRIFT model.

Risks to non-target plants resulting from spray drift from ground and aerial applications of chlorsulfuron are dependent upon a number of factors. This analysis suggests that most plant species are likely to be affected at low levels (10% reductions in shoot weight) more than 1000 feet downwind of applications conducted in winds speeds of 10 mph. Under certain conditions, 80% effect levels may occur to more sensitive species at 1000 feet or more downwind. Higher effect levels are triggered more frequently by aerial applications than with ground boom applications and more frequently with finer sprays.

Laboratory toxicity data used in this analysis were limited to effects occurring in a relatively short amount of time after a single exposure. A number of published reports suggest that chlorsulfuron, and other herbicides with the same mode of action, may result in delayed effects on crop yield and plant reproduction at levels lower than those noted to cause short-term visible effects (for a review see Ferenc 2001). If reproductive effects occur at similar or lower levels than laboratory phytotoxicity data used in this analysis, delayed effects may occur at distances substantially greater than 1000 feet from applications.

Background

Mode of Action

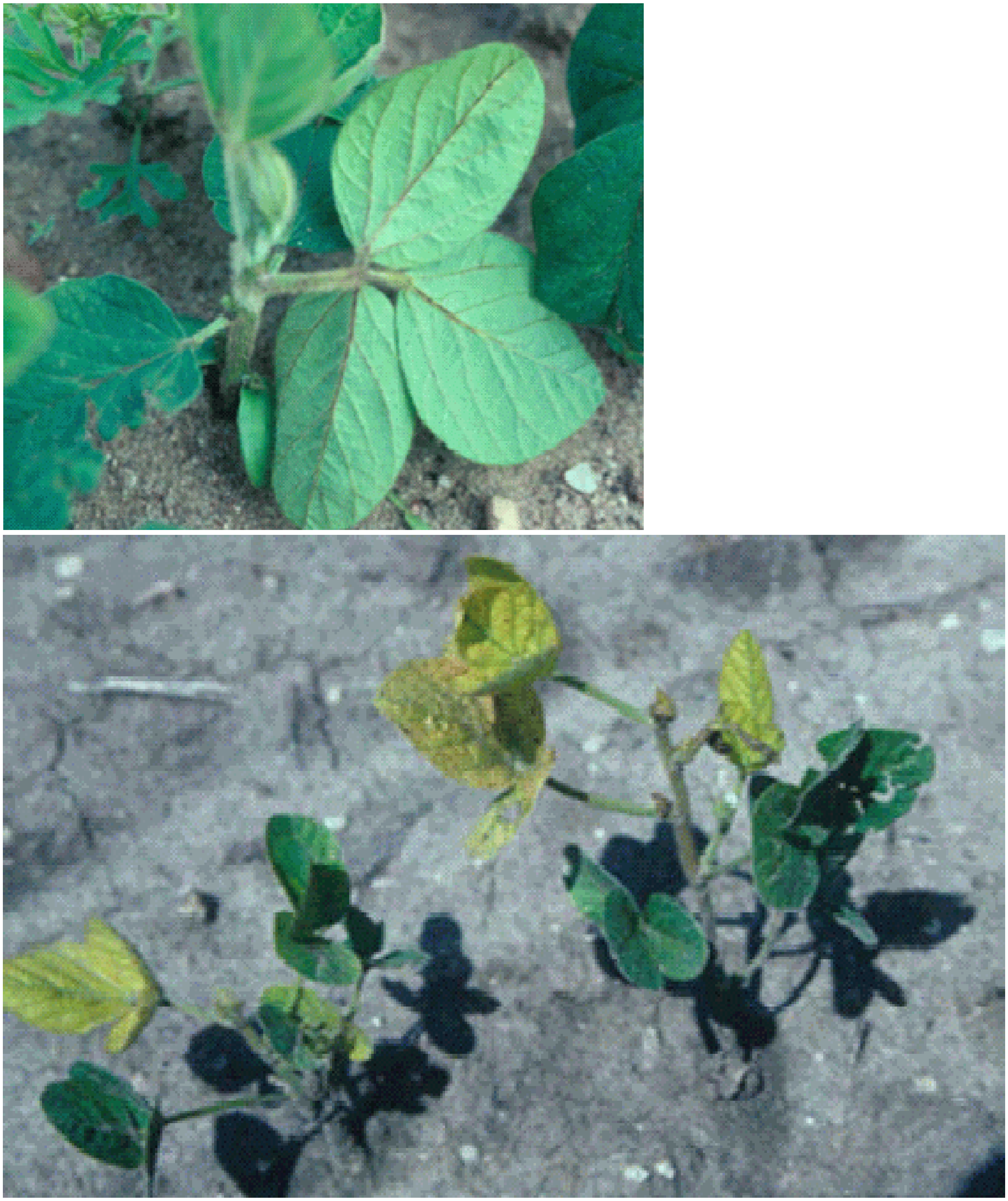
Chlorsulfuron's herbicidal effect results from its inhibition of an enzyme involved in amino acid biosynthesis. It may be absorbed either through the roots or the foliage and is mobile within the plant and binds to the acetolactate synthase enzyme. Soil moisture increases the phytotoxicity of chlorsulfuron by increasing availability and absorption by the roots. Although chlorsulfuron is herbicidal when absorbed by roots, herbicide which contacts foliage is also phytotoxic. Foliar absorption may increase when chlorsulfuron is tank mixed with an oil or surfactant. Chlorsulfuron may be applied either pre- or post emergence. Phytotoxicity data show that chlorsulfuron affects plants in both seedling emergence and the vegetative vigor tests at low levels. Chlorsulfuron tolerant plants, such as grains, resist herbicidal effects by metabolizing the herbicide before it causes toxicity (Weed Science Society 1989).

Plant Symptoms

Chlorsulfuron exposure may cause visible symptoms in days or weeks or delayed effects on reproduction (fruit and seed production) may occur weeks or months after exposure.

Plants that have absorbed sufficient chlorsulfuron on their foliage, in the short term, may show initial symptoms of spotting, and leaf puckering or twisting (Felsot et al 1996). Exposed plants also may show chlorosis and discolored veins (http://www.psu.missouri.edu/soydoc/files/weed/aasynthesis.htm).

Figure 1. Signs of chlorsulfuron induced phytotoxicity. Reddish colored veins (top) and chlorosis (bottom) are apparent.



Chlorsulfuron symptoms may become more pronounced and lead to plant death or the plant may outgrow the symptoms in 1 to 2 months depending on the sensitivity of the plant and the magnitude of the exposure. Developmental/reproductive effects of chlorsulfuron exposure may not be apparent for three or more months after exposure. Reduced seed and fruit development resulting from chlorsulfuron exposure has been documented in canola, smartweed, soybean, and sunflower (Fletcher et al 1996). Because reproductive effects may occur in the absence of other more immediate symptoms of herbicide exposure, it is expected to be difficult to recognize delayed chlorsulfuron toxicity in the field.

Use Pattern

Chlorsulfuron is used predominately on grain crops such as wheat. According to the USGS and USDA, this use accounts for more than 98% of agricultural chlorsulfuron usage (http://ca.water.usgs.gov/pnsp/use92/chlrsulf.html). The maximum application rate for wheat on the Glean product label 0.023 lbs active ingredient/acre. Product label rates for wheat are 0.0078 to 0.016 lbs ai /acre with application per crop (Finesse product label). Up to 0.0625 lbs ai/acre may be used on turf and higher application rates are allowed for industrial areas.

Chlorsulfuron is applied as a liquid spray and, for most uses, may be applied by ground or air. Directions for ground applications to wheat (Glean label) suggest that spray volume should be at least 3 gallons/acre for flat fan nozzles or 20 gallons/acre for Raindrop or flood jet nozzles. The lower volume is presumably allowed for the flat fan nozzle because this commonly used nozzle can produce a fine enough spray to cover the field with the low volume of 3 gallons/acre. With a volume of 3 gallons/acre, a relatively coarse spray would result in too few drops per unit area to adequately distribute the herbicide and control weeds in that area. Raindrop and flood jet nozzles are two models of nozzle that can be used to produce coarser sprays. With coarser sprays, higher volumes are generally necessary to result in adequate coverage of treated fields and weeds for control. (For information on the design of flat fan and flood jet nozzles and their relative drift levels see http://www.hardi-international.com/Agronomy/Education_Material/pdf/04a.pdf or http://lancaster.unl.edu/ag/factsheets/289.htm).

DuPont conducted a small survey of aerial applicators as an indication of typical aerial application parameters (see Appendix 1). The DuPont survey included 15 aircraft set ups for chlorsulfuron applications in Washington and Oregon. Reported in the survey is the application volume (gallons per acre), boom length (relative to wingspan), nozzle type, nozzle angle, aircraft speed, spray pressure, and variables that were assumed in order to calculate spray droplet size. The droplets size spectra estimated from the equipment variables ranged from ASAE medium to ASAE coarse.

Toxicity

The standard toxicity level EFED uses for calculating risk quotients for non-endangered terrestrial plants is the EC_{25}. For endangered plants, the EC_{05} or the no observable adverse effect level (NOAEL) is used. The EC_x effect level represents an X% effect to a group of plants. The dose required to cause a 25% reduction in the average shoot height of a group of plants is an example of an EC_{25} toxicity level. Reduction in the dry weight of the plant can also be used in calculating the EC_x. Visual effects, such as spotting or chlorosis, are not generally assessed because of difficulty in quantifying the magnitude of the effect.

Toxicity tables for the successive plant life stages (seedling emergence and vegetative vigor) from EFED's RED chapter (Balluff et al 2003) are attached in Appendix 2. The most sensitive species tested were sugarbeet (seedling emergence, EC_{25} 3.8×10^{-5} lbs ai/acre) and onion (vegetative vigor, EC_{25} 4.4×10^{-6} lbs/ai acre). The most sensitive effects measured in these tests were reductions in shoot weight and plant height. The phytotoxicity data was limited in that the confidence in the estimated EC_{05} and NOAEL was low.

Non-target plants exposed to herbicides may be killed outright or weakened, reducing their fitness. Non-lethal effects could cause plants to become more susceptible to plant pathogens, become less effective in competing with sympatric species, or reduce reproductive success. In instances where herbicide exposure effects fertilization or seed production, reproduction of plants in the wild would be expected to be reduced and population level changes could occur.

Selection and Representativeness of Plants used in Phytotoxicity Tests

The plants used in phytotoxicity tests are chosen primarily for due to the availability of validated protocols and seed sources. Registrants routinely screen potential products using a wide variety of economically important plants to determine if phytotoxicity concerns exist. The Pesticide Assessment Guideline Subdivision J (EPA-540/9-82-020) states that flexibility is allowed in choosing species in order to maximize use of "...tests that are normally performed by the developer/registrant during screening and initial field testing...." The registrant must test corn and soybeans primarily because of their economic importance in US agricultural. A dicot root crop must also be tested along with an approximately even ratio of dicots and monocots.

The representativeness of plants used in phytotoxicity testing of non-target naturally occurring plants is uncertain. The range of plants used in testing is limited to annuals despite the fact that woody plants and other perennials are commonly found in agricultural areas. Moreover, homogenous crop test plant seed lots lack the variation that occurs in natural populations, so the test plants are likely to have less variation in response than would be expected from wild populations.

In some instances, specific test species may be indicative of an effect to another naturally occurring non-target species. Native plants sharing species, genus or family affinity with the tested crop plant may show similar levels of sensitivity to a pesticide. For instance wild onions may show similar sensitivity to commercially grown onions to a particular herbicide. However, given the intensive breeding and selection that is used to develop commercial strains of a species, it is possible that natural and commercial plants of the same species may show very different responses.

Phytotoxicity Tests and Spray Drift

Spray drift exposure to plants away from field edges is expected to result in relatively few concentrated droplets depositing on and around plants. In contrast, laboratory vegetative vigor and seedling emergence phytotoxicity tests, use relatively high volumes of spray to better cover the test plant or the soil surface. In instances where an herbicide's movement in plants or soil is limited, the test conditions of the phytotoxicity studies may result in higher measured toxicity than would result from spray drift away from the field's edge. In the instance of herbicides that are mobile within plants and soil, such as chlorsulfuron which is mobile in soil and can be transported throughout exposed plants, the volume of spray used for the exposure may not alter the magnitude of the toxic effect.

Exposure

<u>Current Label Directions</u>

This assessment focuses on the effects of spray drift on non-target terrestrial plants. Exposure from chlorsulfuron runoff can also cause phytotoxicity to non-target plants. Chlorsulfuron's mobility and persistence in soil suggests that runoff may be an important route of exposure to non-target plants down slope of application areas. Plants in up-slope areas are not affected by runoff but may be damaged by spray drift.

Chlorsulfuron product labels have very few restrictions on how and under what conditions the product may be applied. For instance there are no droplet size, wind speed, or boom height restrictions. The absence of bounds makes it more difficult to determine what conditions should be used for risk assessment. The absence of basic mandatory label language also allows applicators to make unnecessarily high drift applications. Applicator common sense would prevent worst case applications but may not result in optimal applications. For instance it is unlikely that an applicator would make a ground boom application with a high boom and a fine spray because drifting spray would be visible and it would be apparent that the efficiency of the application was low. However, without proper guidance an applicator may use a low boom but a finer spray than necessary to achieve control. Under this scenario drifting spray would be less visible but still unnecessarily high. Specifying basic spray drift control measures provides applicators with the necessary information to perform an effective and low-drift application and risk assessors with the necessary information to model drift.

AgDRIFT Background

AgDRIFT is a computer model that can be used to estimate downwind deposition of spray drift from aerial, ground boom, and orchard and vineyard airblast applications. The model contains three tiers of increasing complexity. In Tier 1, the user can assess downwind deposition from a single application from all three application methods under default conditions. The current version of AgDRIFT only allows Tier 1 level analyses for ground and airblast application methods. In higher tiers more options are available for aerial applications. The aerial portion of the model is based on a mechanistic US Forest Service model (AGDISP. Bilanin et al 1989). The ground boom and orchard airblast portions are empirical models based on data collected by the Spray Drift Task Force (SDTF). The SDTF field data were used to validate the aerial portion of AgDRIFT (Bird et al 1996a and 1996b). AgDRIFT was developed under a cooperative research and development agreement between EPA, USDA, and the SDTF.

Aerial AgDRIFT: The most important factors affecting drift from aerial applications are spray quality (droplet size), release height, and wind speed. The aerial part of the model predicts mean values based on the inputs provided. The Tier 1 aerial results are generated using the specified droplet size spectra, 10 foot release height, and a 10 mph wind speed. When wind speed and/or release height is lower than the modeled values the spray drift levels would be expected to be lower. Conversely, in instances where applications may be made in higher wind speeds or at a higher release height these inputs may not be adequately conservative and higher tier modeling may be necessary.

Ground boom sprayers in AgDRIFT: The most important factors affecting drift from ground boom applications are spray quality, release height, and wind speed. The ground boom part of AgDRIFT is based on field trial data from bare ground applications. The results of the model reflect the quality and conditions of the data on which it is based. The data from the field trials were grouped into categories by spray quality (droplet size) and release height. Results from field trials conducted with different wind speeds were averaged. The average wind speed over all the trials was approximately 10 mph. AgDRIFT outputs for ground boom applications estimate the 50^{th} and 90^{th} percentile of data collected from field trials. For this analysis the 50^{th} percentile data was used. The field trial data were not corrected for incomplete analytical recoveries, suggesting the true mean deposition values would be approximately 20% higher than the model's deposition results.

Phytotoxicity and Downwind Distance

Using the AgDRIFT model (version 2.01) and registrant submitted phytotoxicity data (MRID 42587201, McKelvey and Kuratle 1992) it is possible to estimate distances downwind from application areas at which a particular toxic effect level would be experienced by a particular tested plant species. To make Figures 2 through 7 below, EC_{25} values (for vegetative vigor shoot weight) of the tested species were used with the toxicity slope[1] from each species to calculate EC_{10}, EC_{20}, EC_{30}, to EC_{90} effect levels[2]. These EC_x values were entered into an Excel spreadsheet with Tier 1 AgDRIFT (version 2.01) deposition distance results and the maximum chlorsulfuron application rate for pasture/rangeland (0.0625 lbs ai/acre). Excel then calculated estimated downwind deposition levels for chlorsulfuron use on pasture/rangeland and compared the deposition values to the EC_x values to identify the downwind distance at which the EC_x values would be reached. Excel arranged the distances into three dimensional bar charts showing the downwind distance at which a particular toxicity level for each species is expected to occur under the Tier 1 AgDRIFT conditions with the specified application rate.

The barcharts shown in Figures 2 through 7 are specific to the maximum application rate for pasture/rangeland (0.0625 lbs ai/acre). Appendix 3 contains phytotoxicity barcharts for a middle of the range application rate from the Finesse product label for preemergent spraying to wheat (0.012 lbs ai/acre).

---

[1] Toxicity slopes are calculated from dose-response relationship of chlorsulfuron on of the test plant species. Species with high (steep) slopes show large increases in toxicity from small increases in exposure. Species with low (shallow) slopes show small increases in toxicity from relatively large increases in exposure.

[2] A log normal toxicity distribution is assumed. The following equation is used to calculate the various EC_x levels: $[EC_{25} / 10^{-0.67/slope}] \times 10^{-a/slope} = EC_x$ where a = 1.28, 0.84, 0.54, 0.25, 0, -0.25, -0.54, -0.84, and -1.28 for EC_{10}, EC_{20}, EC_{30}, EC_{40}, EC_{50}, EC_{60}, EC_{70}, EC_{80}, EC_{90}, respectively.

Figure 2. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **coarse** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.0625 lbs chlorsulfuron per acre. The plant species listed on the bottom right axis are test species for which the registrant submitted phytotoxicity data (the toxicity slope for cucumber was unavailable so cucumber results are not shown).

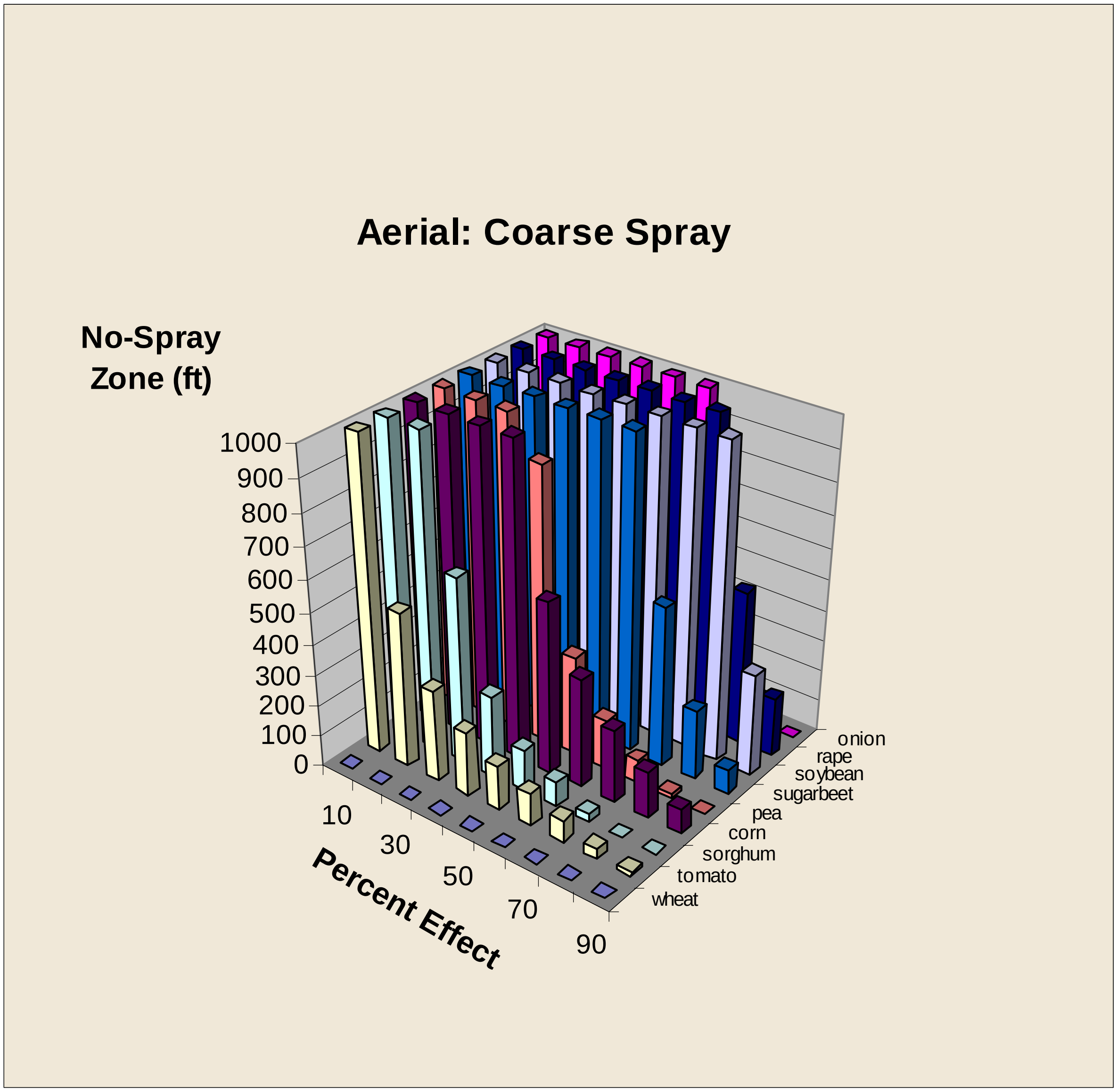


Figure 3. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **medium** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

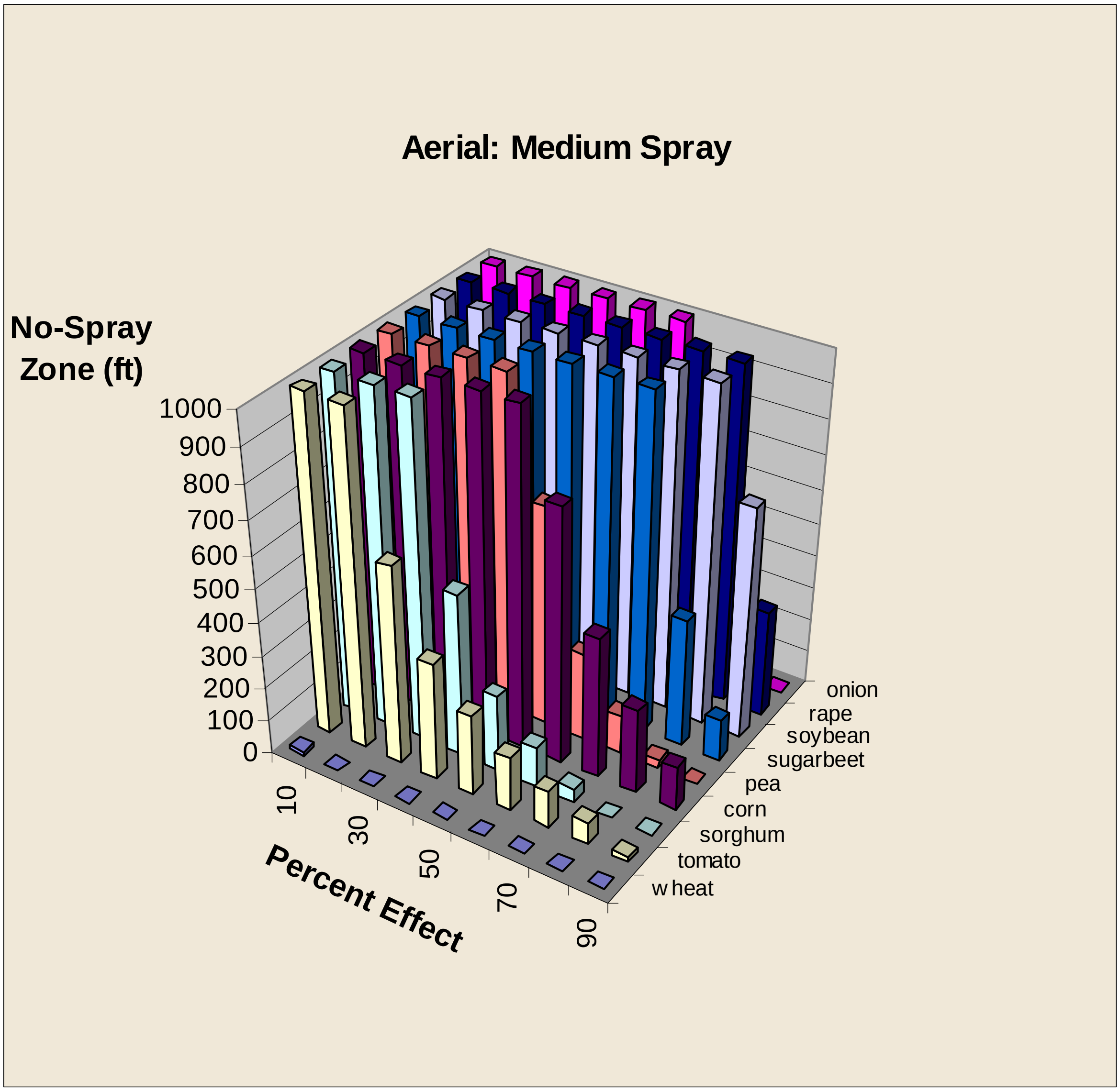


Figure 4. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

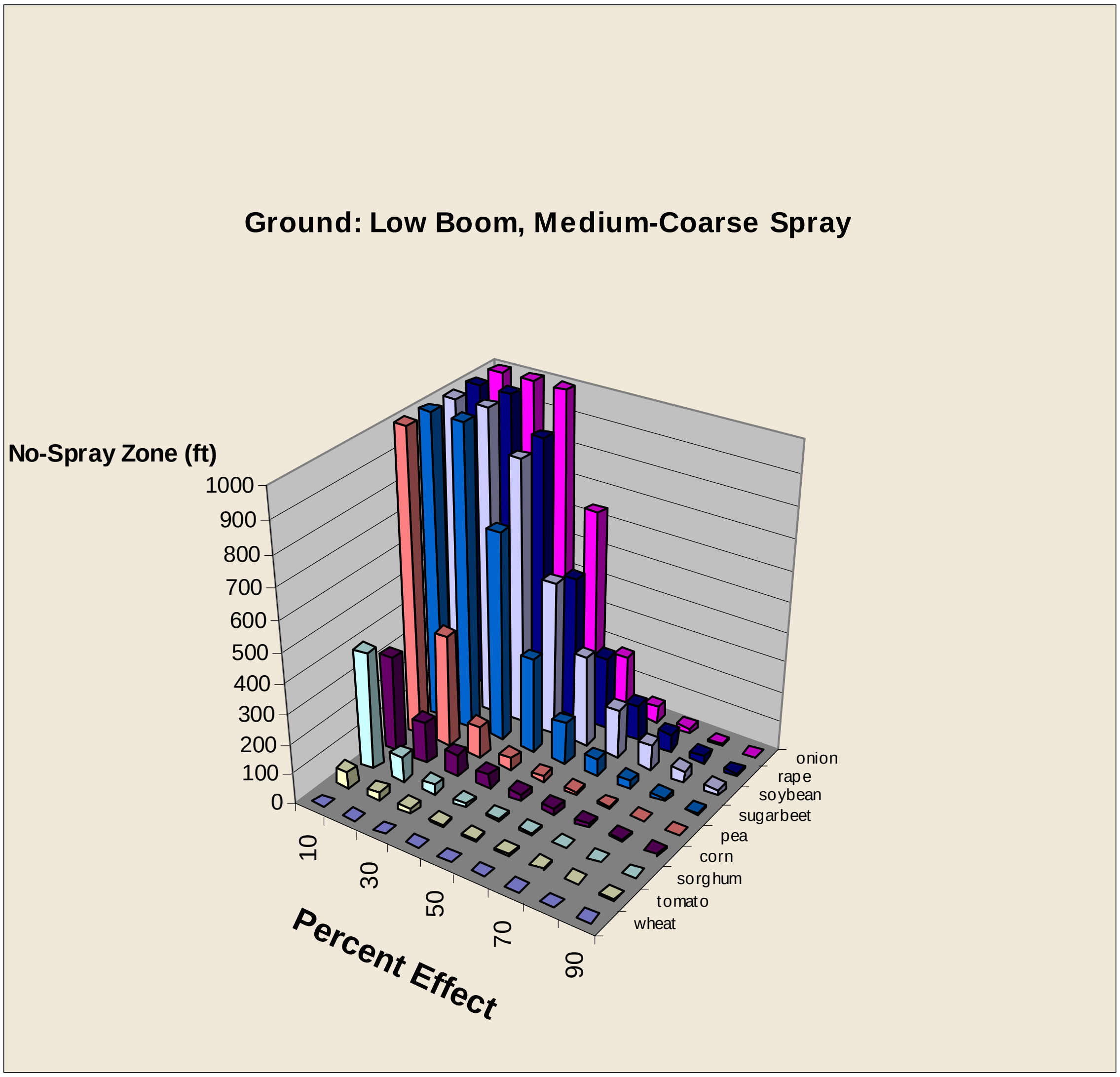


Figure 5. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

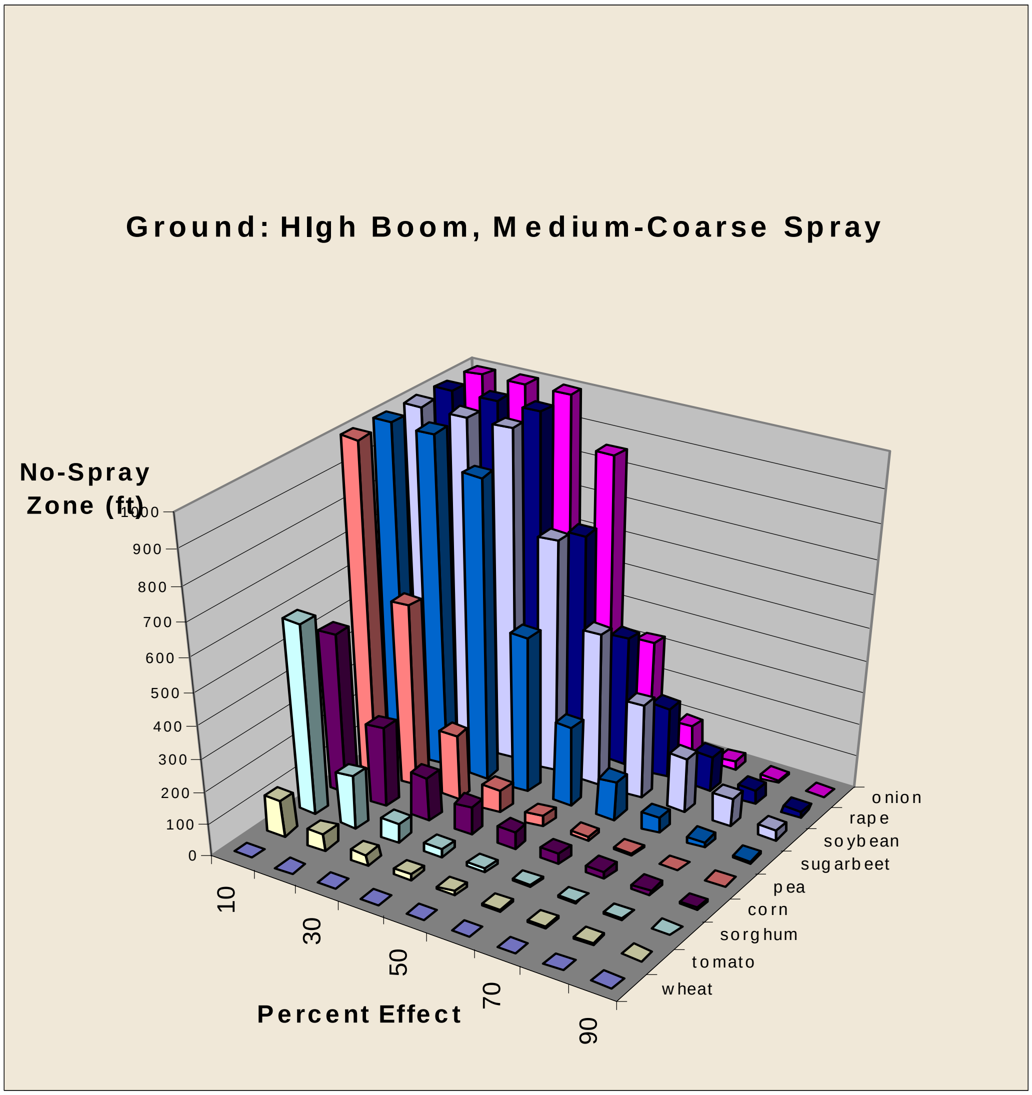


Figure 6. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

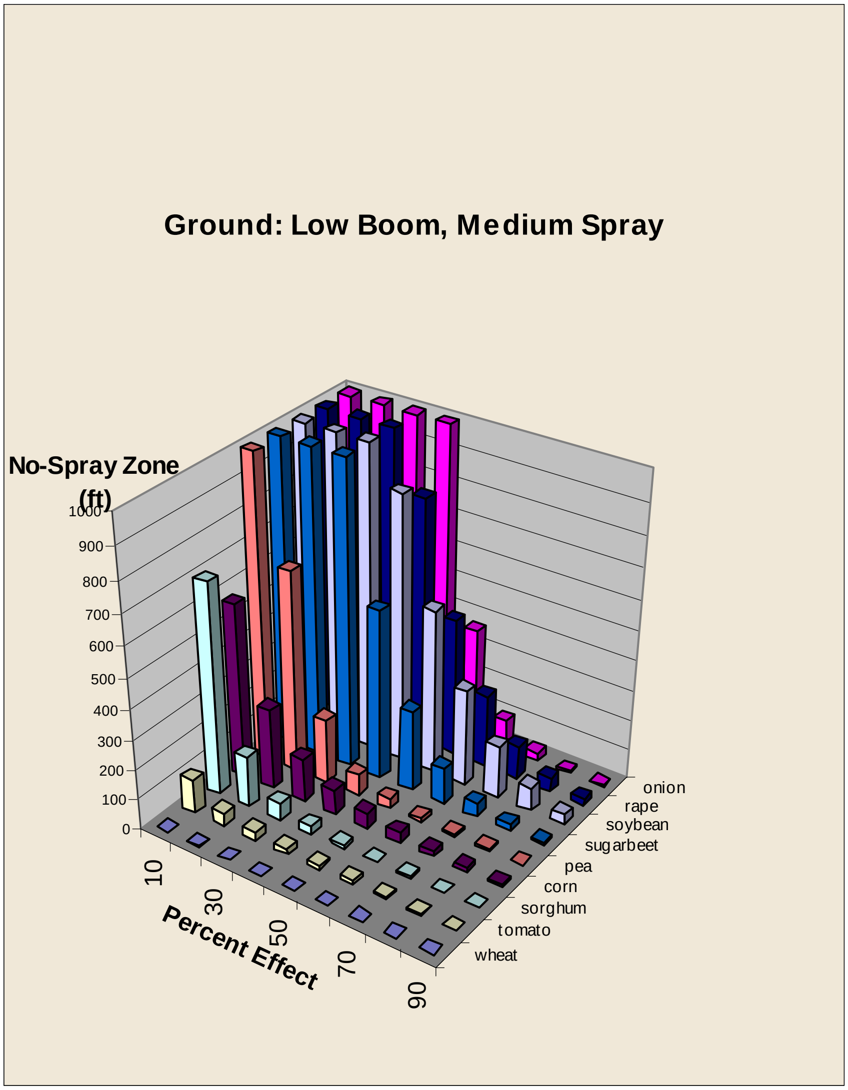
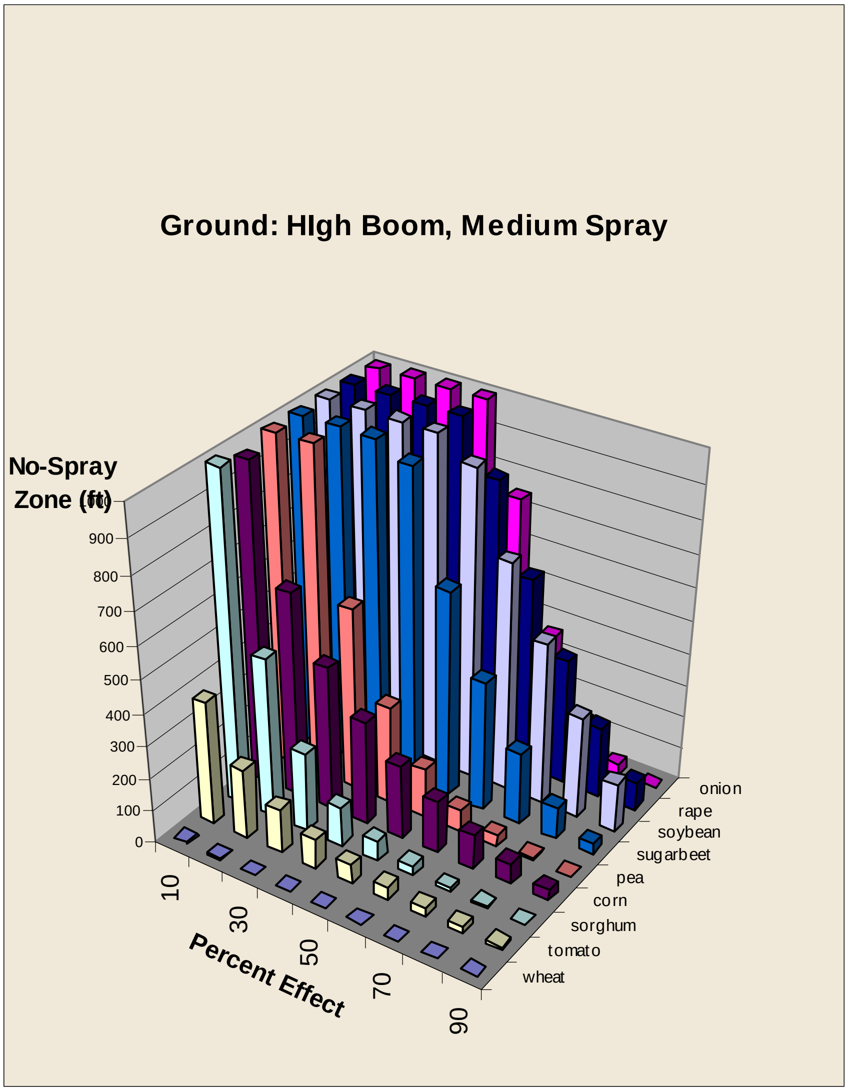


Figure 7. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.0625 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.



Discussion

Based on the phytotoxicity study results for wheat and chlorsulfuron use sites such as pasture/range land, certain grass species appear to be tolerant to acute chlorsulfuron effects. Some tolerant species apparently are susceptible to reproductive effects from single exposures based on product claims of inhibiting seed head formation described on some product labels. Because of lack of data, reproductive effects cannot be evaluated at this time. Available data suggest that it is unlikely that field edges and areas downwind comprised of grass would be greatly affect by acute effects of chlorsulfuron.

Figures 2 through 7 above show the phytotoxicity downwind of chlorsulfuron applications is expected to vary based on a number of parameter including application method (ground boom versus aerial), the droplet size spectrum, and the release height.

Figures 2 through 7 show effects (EC_x effect levels) by distance, but do not show at what distance plants are likely to be killed outright. When plants are tested by pesticide companies for efficacy generally a 70% effect level is considered to be a threshold for lethal effects to a healthy weed (Pallett 2003). Thus the EC_{70} effect level can serve as estimate of when non-target plants are expected to have a high likelihood of rapid death similar to the desired effect for weed species.

Aerial

For aerial applications, medium and coarse sprays are apparently the most commonly used sprays by aerial applicators in Washington and Oregon - see Appendix 1. Medium spray is expected to produce higher drift levels than coarse sprays resulting in greater phytotoxicity at greater downwind distances. Using the EC_{70} as an estimate for an exposure that would lead to rapid death, Figure 3 shows that 3 of the 9 tested species downwind of an application with a medium spray would be expected to be killed soon after application in an area stretching from the edge of the treated field to a distance exceeding 1000 feet downwind from the treatment area. Using a coarse spray, Figure 2 shows that 2 of the 9 tested species would be expected to be killed from the edge of the field to a distance exceeding 1000 feet downwind from the treatment area. Aerial applications with a medium spray are expected to affect at least 8 of the 9 species tested at the EC_{20} level or above for shoot weight greater than 1000 feet downwind of applications. In other words, a 20% or more reduction in shoot weight would be expected for at least 8 of 9 tested species for over 1000 feet downwind of applications under the assumed conditions. With a coarse spray, under the same conditions, at least 8 of the 9 tested species are expected to be affected at the EC_{10} level 1000 feet or more downwind (i.e. a 10% reduction in shoot weight in an areas stretching for more than 1000 feet downwind).

Ground boom
In all instances the ground boom applications modeled resulted in lower drift deposition levels and downwind phytotoxicity than modeled aerial applications. Ground boom deposition values were affected by both droplet size and release height. Spray drift and predicted off-target effects can be reduced by lowering the release height and/or increasing spray droplet size.

Under the lowest ground boom drift conditions allowed by AgDRIFT 2.01 (2 foot boom height and medium/coarse spray), 5 of 9 tested species would be expected to be rapidly killed from 10 to 85 feet downwind the treated area (Fig. 4). Under the same conditions, 5 of the 9 tested species would be affected at the EC_{10} level in the area stretching for the edge of the field to beyond 1000 feet downwind.

Under the highest ground boom drift conditions (4 foot boom and medium spray), plant species would be expected to be killed in the area that stretches from 0 to 10 feet (for 8 of 9 tested plants) and 0 to 500 feet (for the most sensitive tested plant) downwind of the treated field (Fig. 7). Under the same conditions, 6-7 of the 10 tested species are expected to be affected at the EC_{10} level at distances from 0 to beyond 1000 feet downwind. Tested species are expected to be affected at the 90% effect level at 10 feet (5 of 9 species) to 150 feet (1 of 9 species) downwind.

Labeling
The results of this analysis suggest that mandatory product labeling placing restrictions on droplet size for aerial applications and droplet size and boom height for ground boom application may reduce risks associated with chlorsulfuron applications.

An example of potential mandatory product labeling that would be expected to result in average non-target plant risks equal to or less than those presented in Figures 2 though 7 above is:

> For ground boom applications, apply with nozzle height no more than 2 feet above the ground or crop canopy and when wind speed is 10 mph or less at the application site as measured by an anemometer. Use “very coarse” or coarser spray according to ASAE 572 definition for standard nozzles.
>
> For aerial applications, the boom width must not exceed 75% of the wingspan or 90% of the rotary blade. Use upwind swath displacement and apply only when wind speed is between 3 and 10 mph. Use “coarse” or coarser spray according to ASAE 572 definition for standard nozzles.

Typical values for both wind speed and release height are likely to vary geographically. Aerial applicators balance low release heights with flight safety. Aerial applicators will generally use higher release heights in hilly areas or fields with tall windbreaks at their boundaries. For ground boom applications, high release heights are used to avoid having the ends of the spray boom hitting the ground in uneven fields or when relatively high sprayer speed is desired. Gorund boom relaease height can vary from less than 2 feet to more than 6 feet above the ground or crop camopy. Average wind speed for chlorsulfuron use areas vary with location with higher wind speed occurring in plains states. Table 1 shows wind speeds ranges for some representative areas.

Table 1. Wind speeds during the windiest month of the year for cities in high agricultural chlorsulfuron use areas.

City, State	Approximate location in state	Month	Wind speed (mph)		
			75th Percentile	50th Percentile	25th Percentile
Yakima, WA	south central	April	10	6	4.5
Pendleton, OR	northwestern	April	10.5	6	4.5
North Platte, NE	central southwestern	April	14	11	7

More wind speed data for the locations in Table 1 are shown in Appendix 4.

Ecological Implications

Chlorsulfuron is a selective herbicide. Some species, such as certain grasses, are relatively tolerant to chlorsulfuron while other species are sensitive to acute effects and reproductive effects. If certain plants in a plant community consisting of many species are consistently selected against through inhibiting growth, reducing reproductive success, or being killed, the sensitive plant species are likely to be removed from the community. Plants under selective pressure are not able to compete as successfully with other plants for resources such as light and water. Thus with pressure on a particular group of species other species would be likely displace the sensitive species and become more common. Changes in the species composition in the boundaries of herbicide-treated fields have been noted in the literature (Kleijn and Snoeijing 1997, Jobin *et al* 1997). Given the selectivity of chlorsulfuron and the drift potential associated with spray application methods, it is expected that chlorsulfuron is applying selective pressure against certain species downwind of application areas. The magnitude of the selective pressure is expected to depend on the level of drift as well as the sensitivity of exposed species.

Uncertainty and Potential Refinement of Risk Estimates

A number of uncertainties exist in this assessment of potential effects of chlorsulfuron spray drift to plants. With additional information addressing uncertainties it may be possible to further refine this assessment. Some uncertainties underlying this assessment exist in:

1) The representativeness of tested species for non-target plant species in chlorsulfuron use areas. In chlorsulfuron use areas woody and other perennial species are exposed to spray drift but their sensitivity to chlorsulfuron is uncertain. Toxicity data on a wider range of plants could be used to reduce uncertainty as to the potential effects of chlorsulfuron on perennial and woody species at field edges and farther downwind.
2) The duration of exposure. Laboratory data is based on single exposures to plants with observation continuing for two weeks after dosing. Non-target plants in chlorsulfuron use areas may be exposed to multiple pulses of chlorsulfuron. Data on the effect of repeat exposures at environmentally relevant levels could be used to determine the potential impacts to plants that are exposed to drift from multiple applications.
3) The toxic endpoint measured. Some chlorsulfuron product labels and research on non-target plants show chlorsulfuron negatively affects plant reproduction. Data defining what exposure levels at various developmental stages result in impaired plant reproduction could be used for assessing potential impacts of spray drift on plant reproduction.
4) The adequacy of laboratory spraying treatments in representing spray drift far from field boundaries. Plants in laboratory studies are exposed to herbicide in volumes of carrier that are adequate to cover the test plants. Plants exposed to spray drift away from field boundaries would contact the same amounts of herbicides tested in the laboratory but in much lower volumes of carrier. Plants are exposed to spray drift away far away from the field edge in discrete spots where droplets impact the plant foliage opposed to the diffuse coating used in lab studies. The effect of small concentrated exposures relative to diffuse exposure is uncertain. Data on the effect of exposure volume on phytotoxicity could be used to refine effect level estimates.

Data addressing the uncertainties above could be used to improve estimates of effects to non-target plants in chlorsulfuron use areas.

References

Balluff, D, and D. Young. 2003. EFED Risk Assessment for the Reregistration Eligibility Decision on Chlorsulfuron. Environmental Fate and Effects Division, Office of Pesticide Programs, US Environmental Protection Agency.

Felsot, AS, MA Bhatti, GI Mink, and G Reisenauer. 1996. Biomonitoring with Sentinel Plants to Assess Exposure of Nontarget Crops to Atmospheric Deposition of Herbicides. *Environmental Toxicology and Chemisty.*. 15(4): 452-459.

Ferenc, SA. (Editor). *Impacts of Low-Dose High-Potency Herbicides on Nontarget and Unintended Plant Species.* Society of Environmental Toxicology and Chemistry. 2001.

Fletcher, JS, TG Pfleeger, HC Ratsch, and R Hayes. 1996. Potential impact of low levels of chlorsulfuron and other herbicides on growth and yield of nontarget plants. *Environmental Toxicology and Chemistry*. 15(7):1189-11-96.

Jobin, B., C Boutin, and JL DesGranges. 1997. Effects of agricultural practices on the flora of hedgerows and woodland edges in southern Quebec. *Can J Plant Sci* 77:293-299.

Kleijn, D., and GI Snoeijing. 1997. Field boundary vegetation and the effects of agrochemical drift: botanical change caused by low levels of herbicide and fertilizer. *Journal of Applied Ecology* 34: 1413-1425.

Pallett, K. Efficacy testing processes in Industry: releveance for NTTP assessment. Efficacy Data Workshop. August 20, 2003. Office of Pesticide Programs, Crystal City, Arlington, VA.

Weed Science Society of America. 1989. *Herbicide Handbook*. Published by the Weed Science Society of America. Champaign, IL.

Appendix 1

Attachment from 5/12/2003 email from Jake Vukich (DuPont) to Tyler Lane (Chemical Review Manager, Special Review and Reregistration Division, OPP, EPA):

Non-Confidential Version of Attachment A to DuPont Letter to USEPA Dated May 2, 2003

In previous correspondence with EPA regarding the droplet size spectrum expected for typical aerial applications of chlorsulfuron products, we proposed a small, informal survey of aerial applicators to determine typical aircraft setups. To that end, we have obtained descriptions of the spray setups used on fifteen aircraft from fourteen applicators in Washington and Oregon.

To minimize drift, the Glean FC and Finesse labels specify the use of solid stream nozzles oriented straight back when the product is applied by air in the vicinity of sensitive crops. As shown in the attached table, most of the aircraft were fitted with solid stream nozzles with a nozzle angle of 0, as recommended on the label.

The drop size distribution was determined by the USDA –ARS model implemented in AgDRIFT® version 2.04. The model provides a drop size spectrum for a spray solution of water containing 0.25% Triton X-100. In general, we expect the drop size distribution from the model to be shifted toward the fine size distribution as compared to the size distribution for typical agricultural products. The inputs to the model - nozzle type, orientation angle, air speed, and pressure - were supplied by the applicators or representative values were selected as indicated in the attached table.

The drop size distributions were evenly split between ASAE medium, medium to coarse, and coarse. The intent of the label recommendations is to produce a drop size spectrum that will minimize drift, and we anticipated that most of the solid stream nozzles and spray settings would produce a coarse size distribution. We attribute the difference between our expectations and the model results primarily to the higher than expected air speed used for applications. We expected that air speeds would be in the range of 100-110 mph, as it was for aircraft 14 and 15 in the attached table. In contrast, 10 of the 15 applicators fly at a speed of 120 mph or higher. The droplet size distribution shifts toward the fine distribution at higher speeds. For example, aircraft 4 flown at 135 mph produces a medium to coarse size distribution, while at 100 mph would produce a very coarse to extremely coarse size distribution, according to the USDA model.

Since the USDA model simulates drop size distributions for a spray solution with low surface tension, those distributions are likely to show a greater volume of fine droplets than would be expected for typical products. Our experience in the Pacific Northwest suggests that the label recommendations have been successful in reducing drift, as compared to the potential indicated by the drop size distributions predicted by the USDA model.

Aircraft Setups for Application of Chlorsulfuron Products in Washington and Oregon

Aircraft Setup	GPA	Boom-length	Nozzle type	Angle	Speed	Aircraft	Pressure	Assumed Variables	Droplet spectrum (ASAE)
1	7	65%	CP 30 deg plate	0	90-110	188 Cessna	15 psi	all orifices, 20-40psi, 90-110 mph	Medium
2	5	75%	CP 30 deg plate	0	110-120	Airtractor AT 400 & 502		all orifices, 20-40psi, 110-120 mph	Medium
3	5	75%	D-8	0	115	Thrush S2R-6		DC46 core, 40 psi	Coarse
4	3	68%	Lund multi-tip 8	0	135	Turbine Thrush	40 psi		Medium to coarse
5	3	70%	CP 0 deg	0	125-130	Super Doer Thrush		all orifices, 40 psi	Medium to coarse
6	3	68%	Lund multi-tip -8	0	130	502 & 802 Air Tractor	40 psi		Medium to coarse
7	5	68%	D-8	0,10	100-110	Agcat G164 Super B		40 psi	Coarse
8	3	68%	CP Straight Stream	0	135	Super Doer 1200 Wright 1820		40 psi	Medium to coarse
9	3	68%	Spray Systems D-7 no core	0	120-125	Cessna Husky	20 psi		Medium
10	3 to 5	68%	D8, 10, or 12	35	120	Airtractor AT502 - turbine		DC46 core, 40 psi	Medium

11	5	67%	CP .171 15deg plate	15	120	Agcat	25 psi	used 5 ° plate, 15 not in model	Medium
12	5	67%	D10/46	0	120	Airtractor AT502 - turbine	30 psi		Medium to coarse
13	5	67%	D10	0	120	Airtractor AT502 - turbine		DC46 core, 40 psi	Coarse
14	3	68%	CP solid stream, no plate	0	115	Air tractor	40 psi		Coarse
15	7.5	60%	CP solid stream, no plate	0	105-115	Turbo Agcat	22 psi		Coarse

Appendix 2

Non-target Terrestrial Plant Seedling Emergence Toxicity (Tier II) for 98.2% Chlorsulfuron with buffer and Valent X-77 surfactant in some solutions.

Species	% ai	Endpoints	NOAEL / EC25 (lbs ai/A)	MRID No. Author/Year	Study Classification
Cucumber	98.2	Plant height Emergence	0.000035 / 0.00025 >0.00439 / ND	42587201 McKelvey, R.A., and Kuratle, H. 1992	Supplemental
Pea		Plant height Emergence	0.000035 / 0.000113 0.000176 / 0.000281		
Rape		Plant height Emergence	0.000035 / 0.000113 >0.00439 / ND		
Soybean		Plant height Emergence	0.000875 / 0.0015 >0.00439 / ND		
Sugarbeet *		Plant height Emergence	0.0000068 / 0.000038 0.000176 / 0.000281		
Tomato		Plant height Emergence	0.0000351 / 0.000169 >0.02194 / ND		
Corn		Plant height Emergence	<0.00035 / 0.0003 0.00439 / 0.05		
Onion		Plant height Emergence	0.000035 / 0.000163 0.000035 / 0.000413		
Sorgum		Plant height Emergence	0.000163 / 0.00138 >0.0219 / ND		

* Used in RQ calculations

Non-target Terrestrial Plant Vegetative Vigor Toxicity (Tier II) for 98.2% Chlorsulfuron with buffer and Valent X-77 surfactant in some solutions.

Species	% ai	Endpoints	NOAEL / EC25 (lbs ai/A)	MRID No. Author/Year	Study Classification
Cucumber	98.2	Plant height Shoot weight	0.000225 / 0.001875 0.001125 / 0.006125	42587201 McKelvey, R.A., and Kuratle, H. 1992	Supplemental
Pea		Plant height Shoot weight	00.00045 / 0.00025 0.000045 / 0.000181		
Rape		Plant height Shoot weight	0.000045 / 0.0001 0.0000087 / 0.0002		
Soybean		Plant height Shoot weight	0.000045 / 0.0000443 0.0000087 / 0.0000193		
Sugarbeet		Plant height Shoot weight	0.0000087 / 0.0002062 0.0000087 / 0.0000268		
Tomato		Plant height Shoot weight	0.000045 / 0.002 0.000045 / 0.0005562		
Corn		Plant height Shoot weight	0.000225 / 0.000625 0.000225 / 0.0001937		
Onion		Plant height Shoot weight *	0.0000087 / 0.0000368 0.0000087 / 0.0000044		
Sorgum		Plant height Shoot weight	0.000225 / 0.002625 <0.000720 / 0.0001562		
Wheat		Plant height Shoot weight	0.001125 / 0.05563 0.02813 / 0.005813		

Non-target Terrestrial Plant Vegetative Vigor Toxicity (Tier II) for 98.2% Chlorsulfuron with buffer and Valent X-77 surfactant in some solutions.

Species	% ai	Endpoints	NOAEL / EC25 (lbs ai/A)	MRID No. Author/Year	Study Classification

* The most sensitive parameter in the vegetative vigor toxicity study was the sugarbeet root weight (EC05 = 0.000000019375 lbs ai/acre). However, the EC05 for onion shoot weight (0.000000045625 lbs ai/acre) was used in the risk assessment for endangered species because this endpoint provided stronger results.

Appendix 3.

Phytotoxicity resulting from spray drift during a medium application rate Finesse product applications to preemergent wheat. The application ranges from 0.0078 to 0.016 lbs ai/acre. The mean of the high and low values was used for these graphs.

Figure 8. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **coarse** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.012 lbs chlorsulfuron per acre. The plant species listed on the bottom right axis are test species for which the registrant submitted phytotoxicity data (the toxicity slope for cucumber was unavailable so cucumber results are not shown).

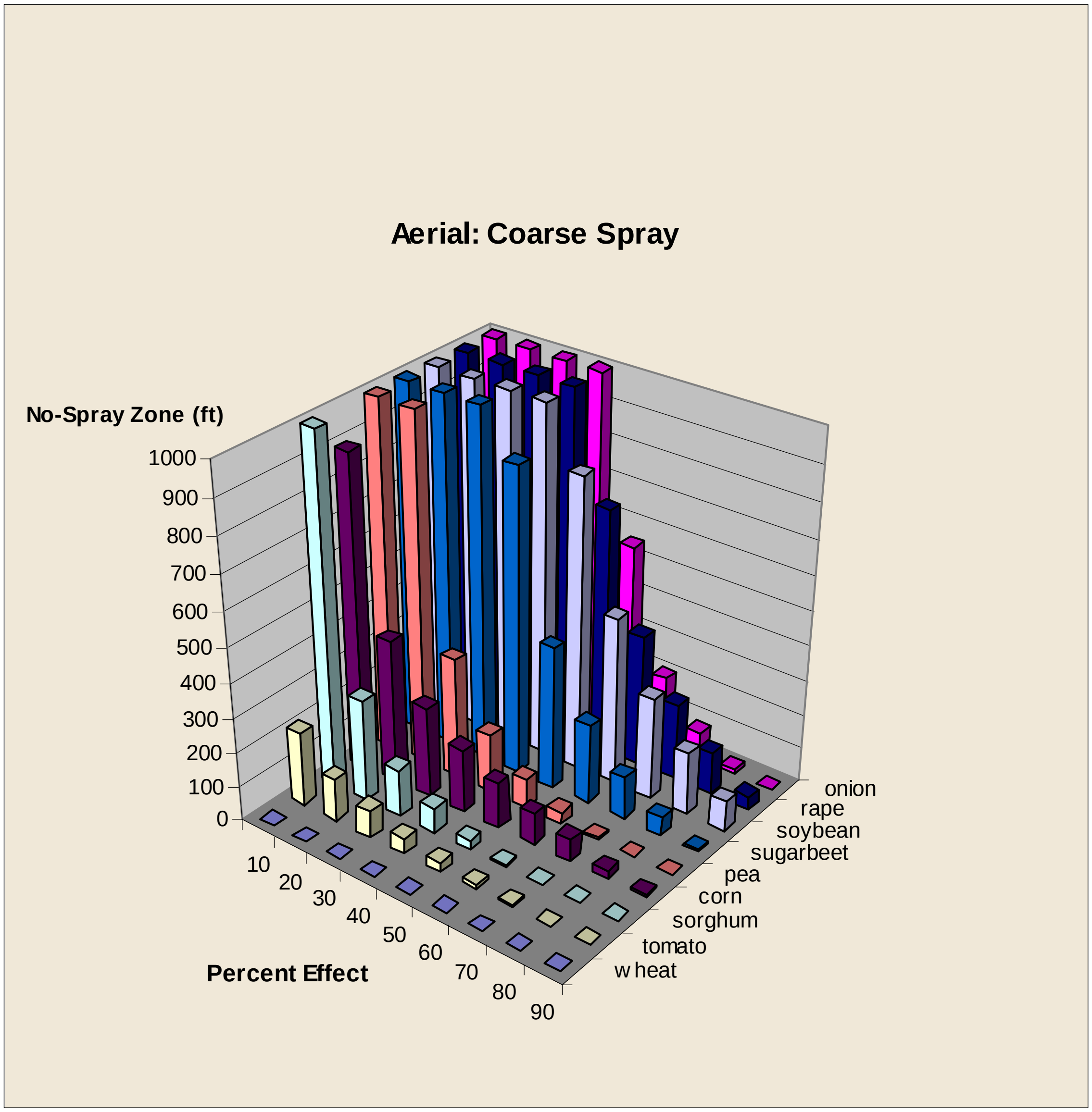


Figure 9. Predicted phytotoxicity levels and associated downwind distances from an **aerial** application conducted with a **medium** spray in a 10 mph wind with a 10 foot release height at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

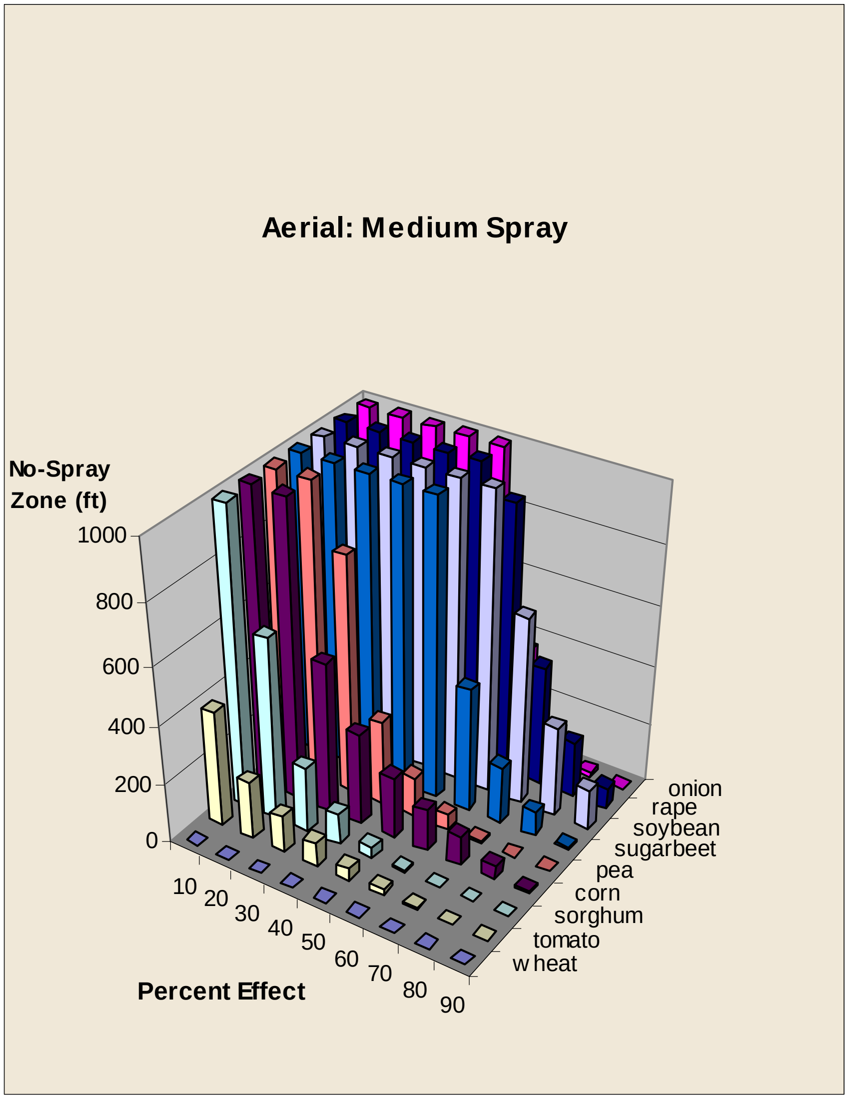


Figure 10. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

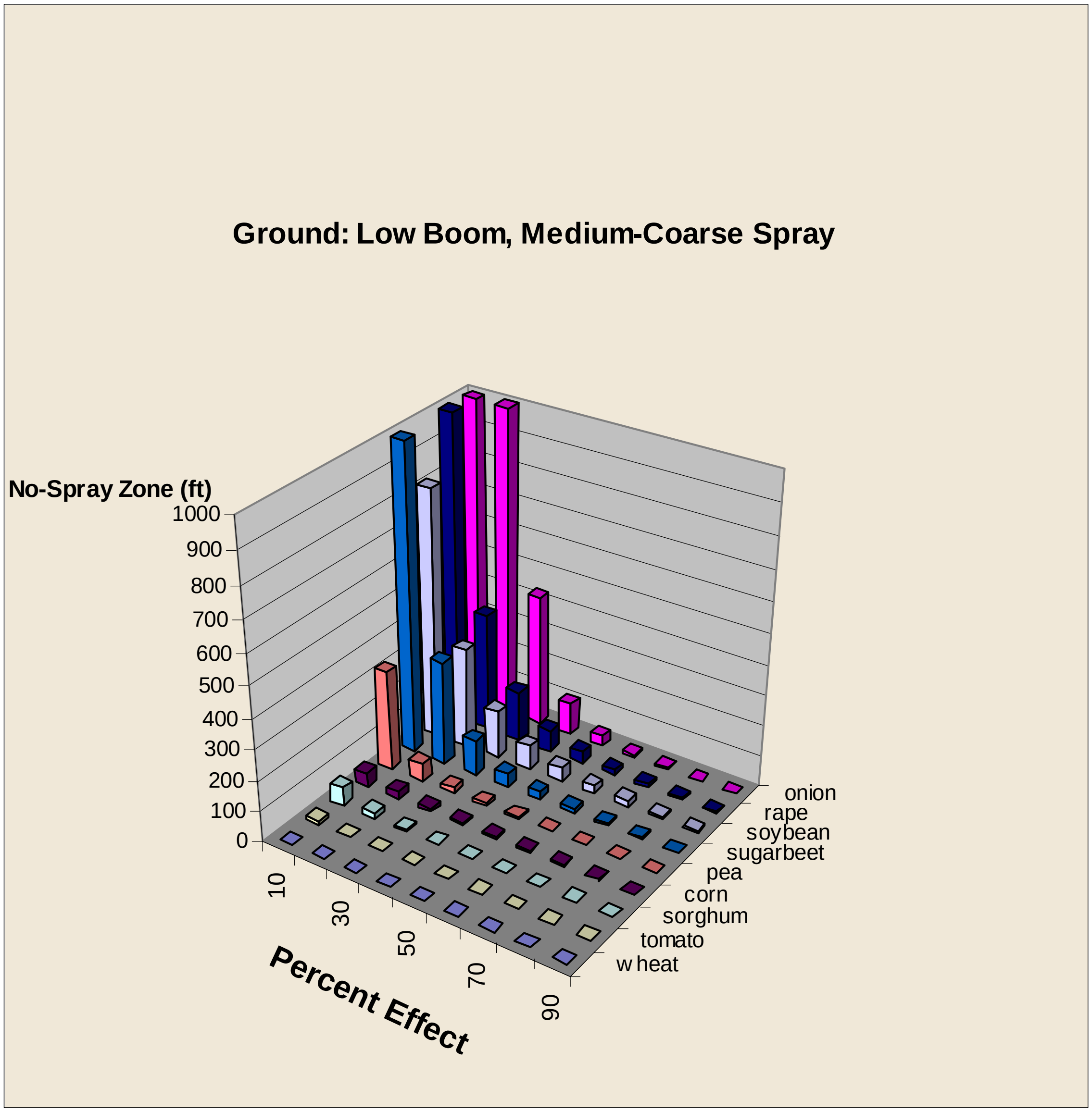


Figure 11. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium/coarse** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

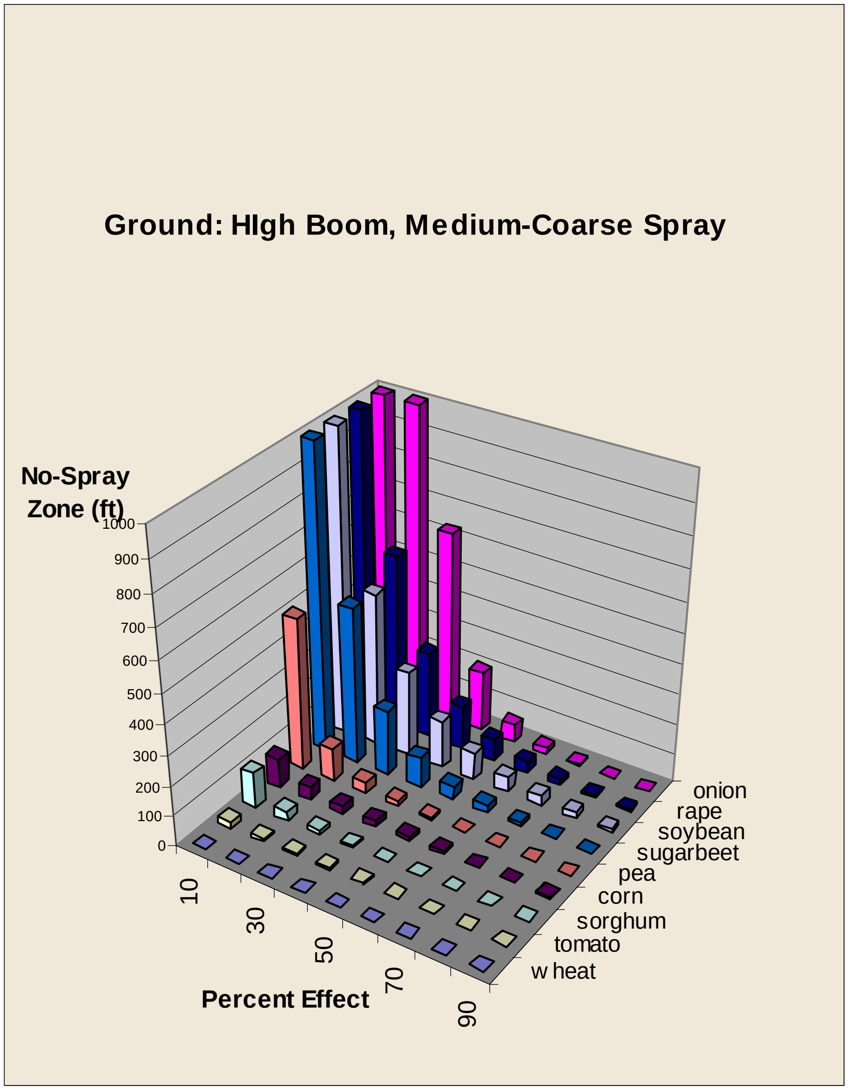


Figure 12. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **2 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.

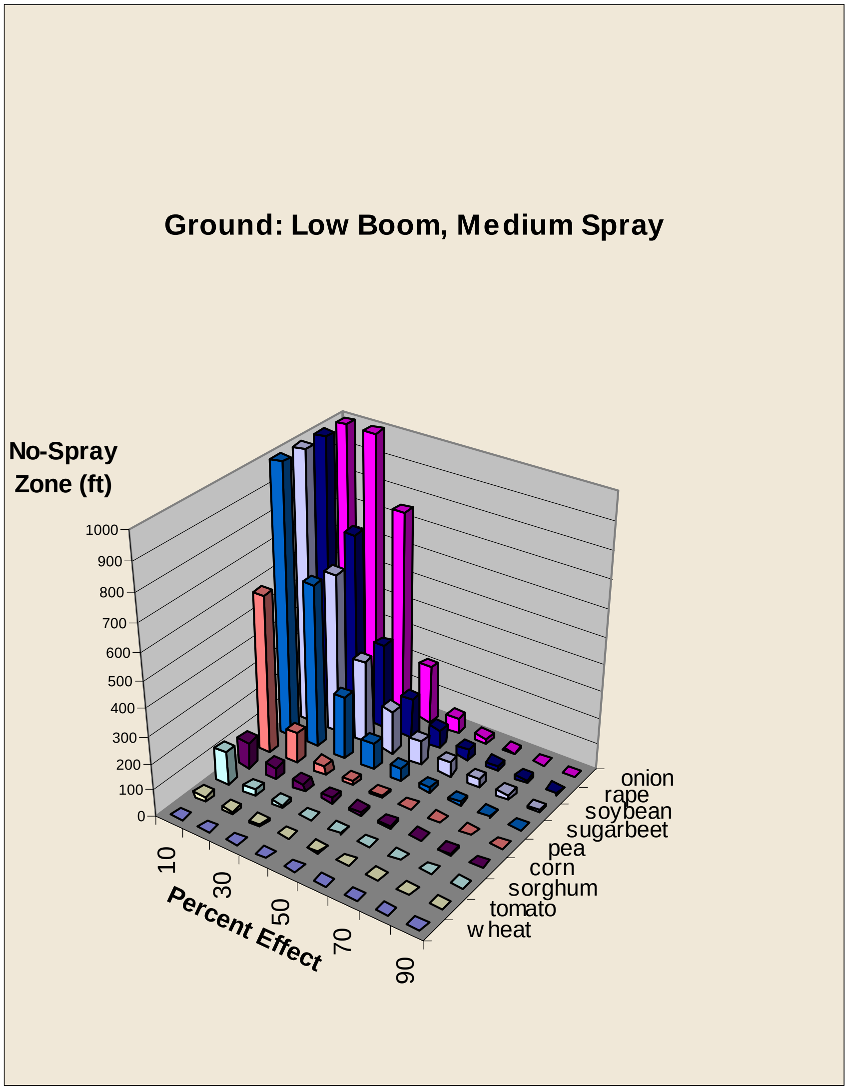
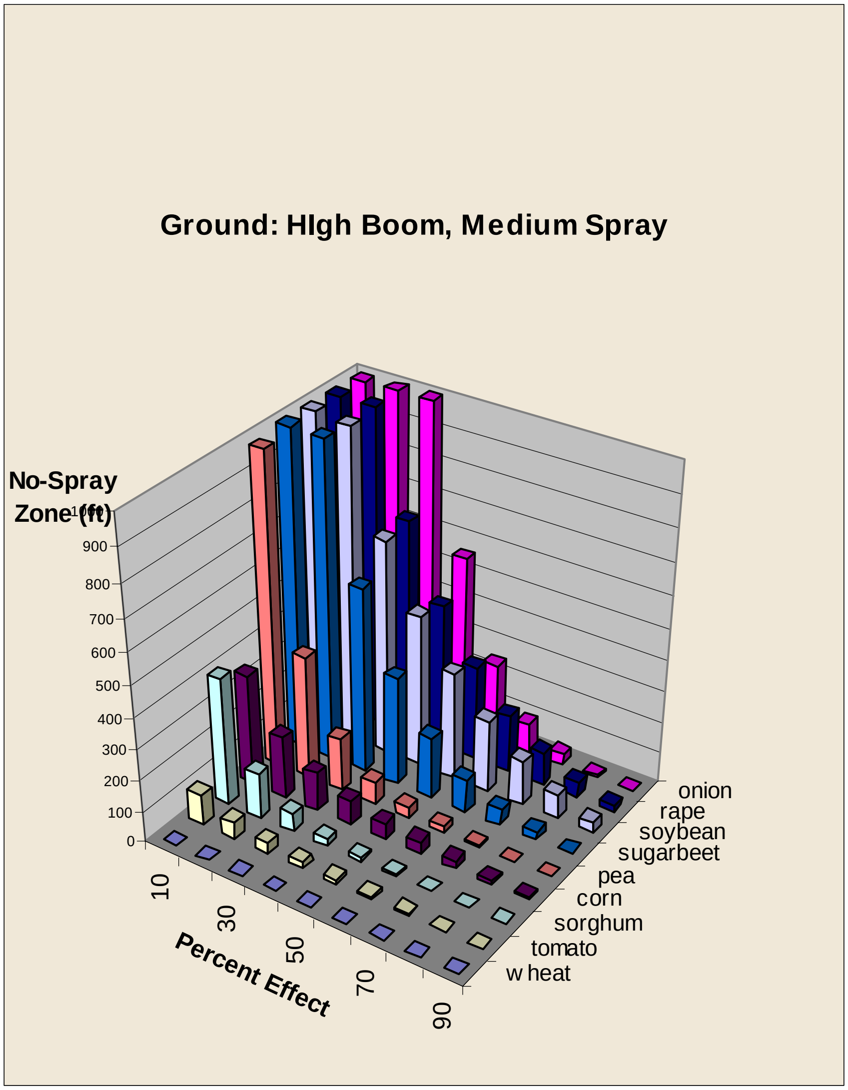
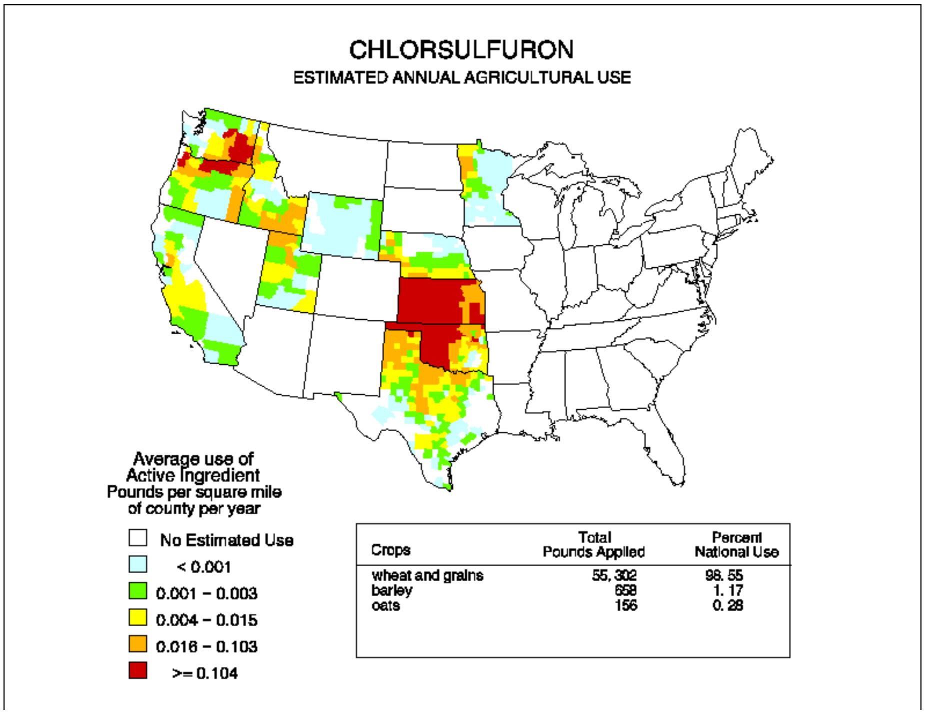


Figure 13. Predicted phytotoxicity levels and associated downwind distances from a **ground boom** application conducted with a **medium** spray in an approximate 10 mph wind with a **4 foot release height** at an application rate of 0.012 lbs chlorsulfuron per acre. The toxicity slope for cucumber was unavailable.



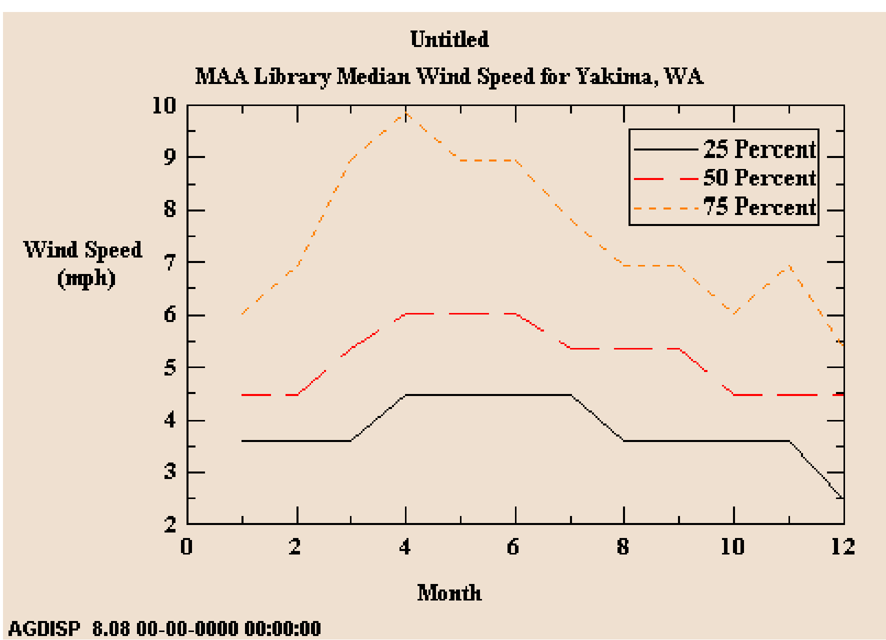
Appendix 4.

Estimated agricultural usage of chlorsulfuron from the US Geological Survey (http://ca.water.usgs.gov/pnsp/use92/chlrsulf.html):

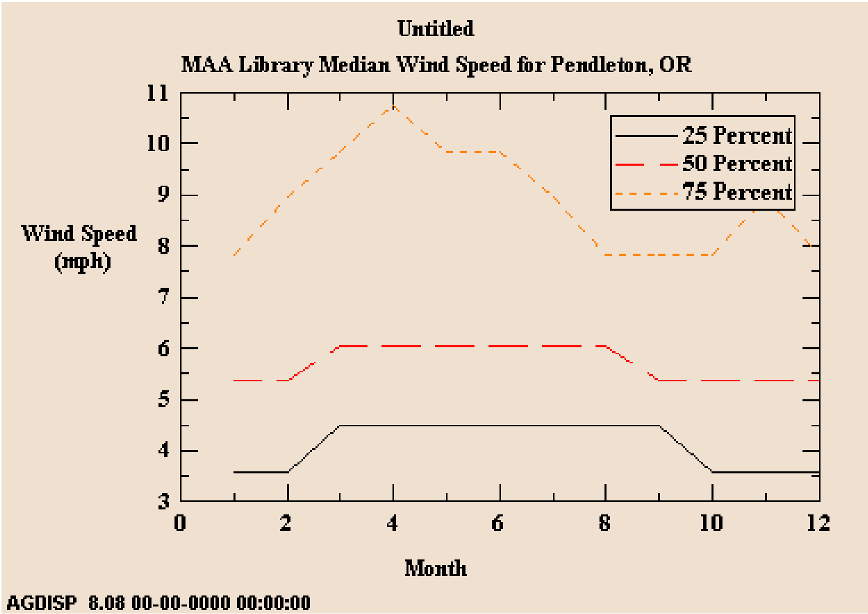


Wind speed data for three representative cities in areas where chlorsulfuron is used agriculturally. Graphs show 75th, 50th, and 25th percentile wind speeds for each month. Wind speed data is from SAMSON weather monitoring stations.

Yakima, south central Washington:



Pendleton, northwestern Oregon:



North Platte, central southwestern Nebraska: